(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: 0 351 197 A2

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 89307051.6

(22) Date of filing: 11.07.89

(51) Int. Cl.5: B 01 D 53/36

(30) Priority: 13.07.88 GB 8816667

(43) Date of publication of application:
17.01.90 Bulletin 90/03

(84) Designated Contracting States:
AT BE CH DE ES FR GB GR IT LI LU NL SE

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(54) Improvements in pollution control.

(57) Pollutants from the exhaust of a lean running internal combustion engine are reduced by the engine having an exhaust catalyst capable of oxidising hydrocarbons and carbon monoxide and reducing NO_x to nitrogen and being fitted with engine management means arranged to provide transient additional enrichment during periods of acceleration. A novel exhaust catalyst for this purpose is carried by a washcoat and is capable of oxidising hydrocarbons and carbon monoxide and reducing NO_x to nitrogen and contains in addition 0.1 - 20% by weight of iron based on the total weight of catalyst and washcoat.

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emissions and is desirably avoided.

The additional enrichment is down to an air to fuel ratio at which the NO_x emissions are reduced when employing a particular catalyst. Preferably, this is down to an air to fuel ratio within 4%, preferably within 2%, either side of the stoichiometric ratio, for instance down to the stoichiometric ratio itself.

The preferred degree of enrichment varies according to engine design and catalyst chosen, but tests on a petrol engine have shown good results with an enrichment to not richer than 14:1, for example at a base lean running mixture of 18.5:1.

The catalyst used preferably includes a component capable of "storing" oxygen and releasing it to oxidise hydrocarbons and CO during the transient additional enrichment, during which the NO_x is reduced to nitrogen, and desirably is formulated to extend the NO_x reduction into the lean running periods. Metal oxides, especially ceria, and mixed metal oxides such as the perovskites for instance lanthanum-barium-cobalt oxide eg $La_{0.8}Ba_{0.2}CoO_3$ have been observed to have this effect, and desirably form one catalyst component. Other catalyst components are necessary to favour oxidation of hydrocarbons and carbon monoxide, and preferably include one or more platinum group metals, such as platinum, rhodium, palladium. Preferably the catalyst comprises platinum and rhodium. Other components such as transition metals or their oxides may desirably be included. The catalysts may be prepared by standard industrial methods. For example, a ceramic or metal monolithic catalyst support, or particulate support, may be coated with a washcoat such as alumina, optionally incorporating the oxygen storage component such as ceria, and the other active catalyst components deposited on the washcoat, in manner known per se.

The exhaust catalyst can be one known per se. The invention provides however a novel catalyst applicable to the present method and engine. This is an exhaust catalyst for an internal combustion engine, which catalyst is carried by a washcoat and is capable of oxidising hydrocarbons and carbon monoxide and reducing NO_x to nitrogen, and which contains in addition 0.1-20% by weight of iron based on the total weight of catalyst and washcoat. This novel catalyst can be prepared in a manner known per se. Its iron content can be for instance 1%.

Engine management systems controlling air/fuel ratios are known and are frequently used in cars for the US market. Basically, a microprocessor can be employed to receive signals from a variety of sensors such as temperature, oxygen content of exhaust, pressure, etc, and vary the air to fuel ratio according to a preset strategy, generally to limit exhaust emissions. It is possible to trigger the initiation of the transient additional enrichments in the present invention in response to inlet manifold pressure change. The skilled person can use suitable engine management means to detect other suitable conditions for initiating, and terminating, the transient additional enrichments.

The invention will now be described with reference to working Examples which are intended for illustrative purposes only.

EXAMPLES 1 & 2

A Volkswagen Jetta Series 1 motor car was fitted with a prototype lean-burn (18.5:1 Air/Fuel) 1500cc engine, a catalytic convertor and a programmable commercial engine management controller. Initial microreactor tests had selected a commercial Three-Way Catalyst (TWC) containing Pt/Fh (5: 1) on a washcoat and such a TWC modified by containing in addition 1% by weight of iron (elemental) based on the total weight of Pt, Rh and washcoat (Catalyst A). The washcoat was a mixture of ceria and alumina containing 25% by weight ceria and was carried on a monolith. Samples of the TWC and Catalyst A were loaded into catalytic convertor cans and the motor car was run on a rolling road over the European ECE-15 and US LA4 test cycles. The test cycles were carried out according to the invention, using catalyst and engine management, with the catalyst alone, with the engine management alone (in two runs only) and compared to the test run on the unmodified engine. The engine management controller was programmed to provide additional enrichment to an air to fuel ratio of 14.5:1 for 1.5 seconds when the inlet manifold pressure rose above 600 mbar. If a short acceleration were followed by conditions of over-run, it would have been undesirable to continue the particular transient enrichment; accordingly, in the particular strategy chosen to programme the controller, the particular transient additional enrichment was terminated if the inlet manifold pressure dropped below 280 mbar. It would have been undesirable for additional enrichment to trip continually in response to small changes in manifold pressure during high speed cruising at a fairly steady inlet manifold pressure around 600 mbar; accordingly, the controller was programmed so that when the pressure fell below 600 mbar, another transient additional enrichment was not initiated until the pressure had dropped below a 550 mbar reset level. The controller also provided full throttle enrichment at inlet manifold pressures above 900 mbar, but did not permit double enrichment.

The results are shown in Tables 1 and 2.

It can be seen that the present invention permits a useful reduction in NO_x and high HC conversions, compared to the vehicle operating with the lean burn engine. The vehicle according to the invention is well within the emission limits. Tests of fuel consumption indicate a 1% penalty, which is considered minimal, and subjective impressions are of improved driveability. It is considered that further improvements within the invention could be obtained by including a feedback fuel management system in the engine control means, and by further modifications to the particular catalyst formulation.

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TABLE 2

LA4 (COLD START) EVALUATION

(a) Three-Way Catalyst

	Without Engine Control	Percentage Change	With Engine Control
Without Catalyst	HC 3.983 g/mile NO_x 2.282 g/mile CO 3.559 g/mile	HC(-23%)NO_x(+16%) → CO(+36%)	HC 3.082g/mile NO_x 2.652g/mile CO 4.849g/mile
Percentage Change	HC (-93%) NO_x (-10%) CO (-68%)	HC (-95%) NO_x (-20%) CO (-68%)	HC (-94%) NO_x (-31%) CO (-76%)
With Catalyst TWC	HC 0.265 g/mile NO_x 2.051 g/mile CO 1.143 g/mile	HC(-25%)NO_x(-11%) → CO (+1%)	HC 0.200g/mile NO_x 1.831g/mile CO 1.153g/mile

(b) Catalyst A

	Without Engine Control	Percentage Change	With Engine Control
Without Catalyst	HC 3.07 g/mile NO_x 2.50 g/mile CO 2.46 g/mile		Not run
Percentage Change	HC (-93%) NO_x (-3.2%) CO (-79%)	HC (-90%) NO_x (-16%) CO (-19%)	
With Catalyst A	HC 0.229 g/mile NO_x 2.42 g/mile CO 0.510 g/mile	HC(+28%)NO_x(-13%) → CO (+292%)	HC 0.293g/mile NO_x 2.11 g/mile CO 2.00 g/mile

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17.01.90 Bulletin 90/03

(84) Designated Contracting States:
AT BE CH DE ES FR GB GR IT LI LU NL SE

(88) Date of deferred publication of the search report:
19.12.90 Bulletin 90/51

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European Patent Office

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing more than ten claims.

☐ All claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for all claims.

☐ Only part of the claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid, namely claims:

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

☒ LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirement of unity of invention and relates to several inventions or groups of inventions, namely:

1. Claims 1-9: Lean running engine with a Pt/Rh/Ce-catalyst and its method of operation.

2. Claim 10: Three-way-catalyst with a washcoat + Fe.

☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☒ None of the further search fees has been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims: 1-9

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